Renewable and Sustainable Energy Reviews 16 (2012) 2618–2630

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Prospects of wind energy sector development in Serbia with relevant regulatory framework overview

Dragan Komarov*, Slobodan Stupar, Aleksandar Simonović, Marija Stanojević

University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, Belgrade, Serbia

ARTICLE INFO

Article history:
Received 1 April 2011
Received in revised form 30 January 2012
Accepted 30 January 2012
Available online 20 March 2012

Keywords:
Wind energy
Wind energy maps
Serbia
Renewable energy sector development
Energy policy

ABSTRACT

The growth of the renewable energy sector in the world in the first decade of the twenty-first century was rapid. Wind energy sector was one of the fastest growing renewable energy technologies. In this paper, authors have tried to review the current state of wind power utilization in Serbia as one of the most penetrating RES technologies in the world. The brief overview of electric power sector in Serbia was given in order to describe the environment for emerging wind energy sector development. Sufficient wind energy resources were identified in several regions of the country. Current energy policy in Serbia was reviewed in terms of the regulations that have to be followed in order to meet the requirements for RES power plants, i.e. wind power plant construction. In subsequent section short reviews of wind energy projects which are in their initial phases are provided. The wind energy sector in Serbia is emerging despite the difficulties faced by the investors, regulatory bodies and other shareholders, in the course of the past several years. There is an urgent need of a broader transfer of specific knowledge and technologies related to wind farms and wind turbines in order to speed up the current wind energy sector development.

Contents

1. Introduction 2618
2. Energy sector in Serbia 2619
3. Wind energy potential in Serbia 2620
4. Legislative framework and technical regulations for wind power sector in Serbia (development) 2623
5. Current developments of the wind energy sector 2626
6. Conclusions 2628
Acknowledgements 2629
References 2629

1. Introduction

Increased energy demand, energy independency and environmental benefits could be considered as the key reasons for rapid growth of renewable energy sources (RES) in the first decade of the twenty-first century. Developed Western countries have been making considerable efforts in order to commercialize various renewable energy technologies that were developed in the second half of the twentieth century, after the oil crisis in 1970s. As renewable energy technologies matured and market grew, interest for renewable energy in the last two decades extended to all key countries in the world. In addition to achieving energy independency, urgent need for greenhouse gases reduction that was formulated in Kyoto protocol resulted in higher penetration of RES, but still substantial efforts are needed in order to achieve set targets even in the most developed countries in terms of RES utilization [1].

Wind turbine industry can be regarded as one of the fastest growing renewable energy technologies in the last twenty years, if compared to other RES [2]. Newly built wind energy capacities in Europe outreached most of newly installed power plants based on conventional energy sources between 2008 and 2010 [3]. The United States established high penetration rate for wind energy in the last few years and gained the leading role in terms of the capacities built annually in the world [4]. China, India and Brazil are some of the established or emerging markets with the growing demand for wind turbines and wind energy utilization [5].

Nowadays high rate of commercial wind energy utilization is mainly due to the steady developments of markets in Denmark,

* Corresponding author.
E-mail addresses: dkomarov@mas.bg.ac.rs, komarovd@gmail.com (D. Komarov).

1364-0321/$ – see front matter.
doi:10.1016/j.rser.2012.01.067

Germany and Spain in the last two decades, and advancements of wind turbine technology made in Denmark, the United States, the Netherlands and Germany in the last thirty years. Wind energy technologies were transferred to the other interested countries and investors, where appropriate wind resource was found and where necessary political will for such projects existed. Enormous growth of wind energy market in China that has substantially been contributing to wind energy penetration rate in the world since 2008 is the most remarkable example of wind energy technology transfer. Several wind turbine manufacturers have emerged in China that have significant role in domestic market [6].

Countries from the EU-15 were global leaders in wind power utilization until recently, which gave the opportunity for all the countries that have joined the EU in the last decade to adopt the current trends more easily, both in terms of the technologies, necessary policy and social issues for development of sustainable local wind power markets. But still, in the EU there is an ongoing debate regarding modes for supporting and promoting sustainable development of RES, and wind energy as one of them [7].

In this paper, authors have tried to review the current state of wind power utilization in Serbia as one of the most penetrating RES technologies in the world. The brief overview of electric power sector in Serbia was given in order to describe the environment for emerging wind energy sector development. Sufficient wind energy resources were identified in several regions of the country [8–10], but already time-consuming wind farm feasibility studies have been prolonged due to the current legislative framework and lack of experience both on the part of competent authorities in terms of the issuance of all required permits and on the part of investors. Some of the identified obstacles for a faster development of wind energy sector in Serbia are common for emerging markets, but also there are specific problems that authorities and investors have to overcome in the future [11]. The experience from developed wind energy markets can point out to the necessary steps in order to overcome these obstacles.

The paper contains six sections: after the introduction and brief overview of renewable energy and wind energy sector trends, Section 2 presents the reviews of installed electric power capacities in Serbia. In Section 3 the wind energy potential in Serbia was reviewed; relevant studies of wind potential were listed chronologically. In Section 4 current energy policy in Serbia was reviewed in terms of the regulations that have to be implemented in order to meet the requirements for RES power plants i.e. wind power plant construction. In subsequent sections short reviews of wind power projects which are in their initial phases are provided with conclusions.

2. Energy sector in Serbia

After the break up of Yugoslavia, under the Law on Electric Power Industry, the Serbian Electric Power Industry (EPS) became (public and) a state-owned enterprise in 1991, which was vertically integrated from coal production to electric power generation, transmission and distribution. Restructuring of EPS was necessary in order to harmonize rules and regulations of the power sector with the European Union (EU) policy requirements. According to the Energy Law from 2004, vertically integrated enterprise has been divided in two public enterprises: one that remained under the same name Serbian Power Industry (EPS) and other was Serbian Power Transmission Company (EMS). The EPS was in charge of electric power generation and distribution and EMS of electric power transmission, transmission system management and electric power market management [12]. A short overview of electrical energy sector and EPS and EMS capacities is given in Table 1.

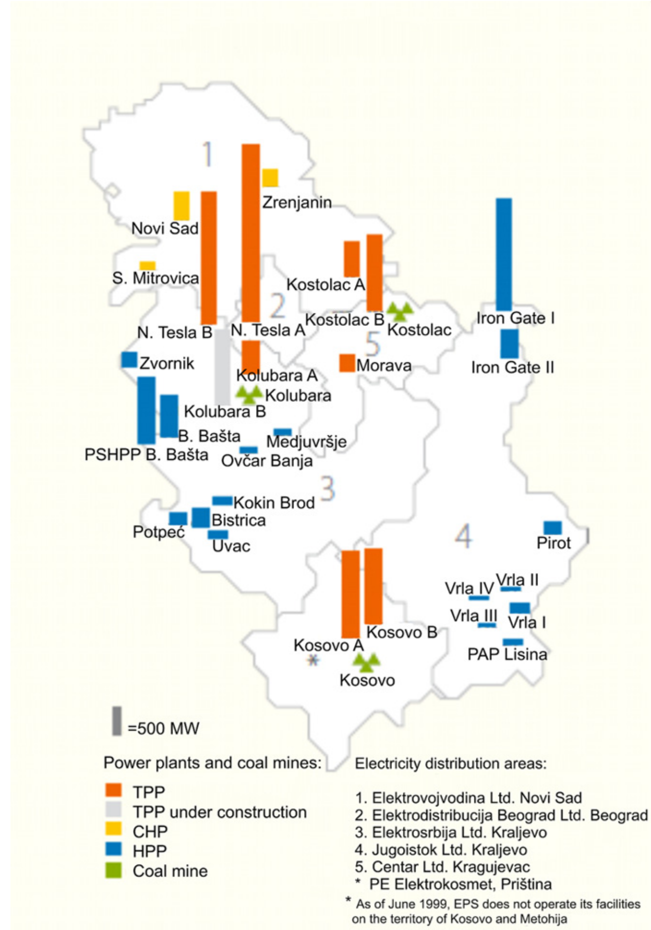


Fig. 1. EPS installed capacities [14].

EPS production capacities by the end of 2009 were as follows: 5171 MW in thermal power plants, 353 MW in combined heat and power plants, 2835 MW in hydro power plants, which totaled to 8359 MW [13], Fig. 1.

Total electrical energy production in 2009 was 41,122 GWh, of which 29,890 GWh was produced in thermal power plants (TPP), 139 GWh in combined heat and power plants (CHP) and 11,093 GWh in hydro power plants (HPP). Overall annual production of power plants between 2001 and 2009, with and without power plants in Kosovo and Metohija, is shown in Figs. 2 and 3.

During the period from 1991 to 2000 there were difficulties in normal operation of power plants due to the lack of regular and proper maintenance and due to energy infrastructure damage made in 1999. Substantial part of subsequent investments in EPS,

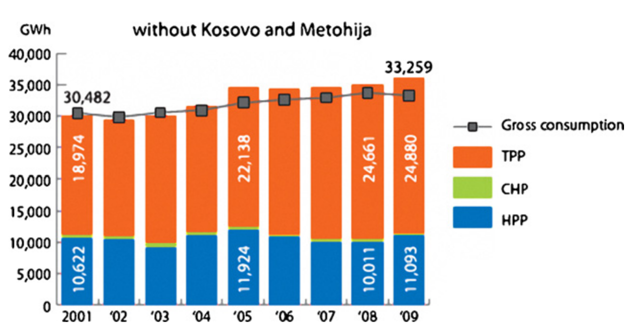


Fig. 2. Electricity generation and gross consumption in Serbia with Kosovo and Metohija [14].

Table 1
Capacities of EPS and EMS.

No	Capacities	Unit	With capacities at Kosovo and Metohija	Without capacities at Kosovo and Metohija
1	Installed capacity of power plants	MW	8359	7124
2	Annual coal production	10^3 tons		37,952
3	Length of distribution network	km		141482.1
4	Installed capacity of transformers in distribution companies	MVA		25413.2
5	Number of consumers	Million		3.43

in the last decade, from own funds, foreign donations and credits were concentrated on revitalization of existing capacities.

According to the Energy Sector Development Strategy [15] adopted by the government, and operation and development program of EPS for the period 2008–2015, some of the EPS objectives have been technical and technological improvements of the company, environmental improvements and development activities oriented towards RES [16]. EPS mainly plans to invest in continual revitalization of existing capacities and in construction of new thermal power and hydro power plants. According to the plan, substantial investments would be made within mining capacities, development of distribution network and environmental protection. In the same plan, it was stated that RES investments by EPS would be directed to construction of small hydro power plants.

The government oriented its strategy towards revitalization of the existing large-scale capacities and construction of new thermal and hydro power plants, although in several documents RES have been identified as strategic orientation of the country [15,17–19]. Current activities in the wind energy sector and the rest of the RES sector are mostly in the initial phase. Estimations of available technical feasible source utilization have been made on the specific locations [20–22], or the projects are in the phase of getting all the necessary permits and legal documents for the construction. The Energy Sector Development Strategy of the Republic of Serbia by 2015 has identified RES as one of the priority programs, right after the priority of continuous technological modernization of existing facilities and energy efficiency, and economical use of quality energy products. Technical available potential of RES in Implementation Program of the Energy Development Strategy of the Republic Serbia by 2012 has been estimated according to the available national researches [23]. The wind energy potential estimation was based on the available data from hydro meteorological stations based on the wind speed measurements taken 10 m above the ground. Biomass and small-scale hydro potential are emphasized as the RES from which the expectations are the greatest, in terms of a high share in the overall renewable resources and the tradition in hydro power plant construction. In the mentioned Implementation Program, it has been stated that financial support should be aimed at these two resources primarily, but financial incentives should be aimed at the thermal solar collectors and gradual construction of

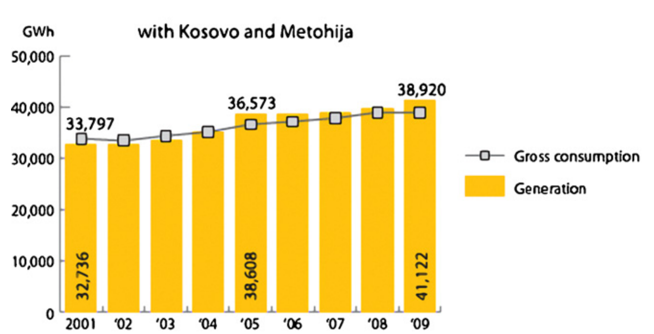


Fig. 3. Electricity generation and gross consumption in Serbia without Kosovo and Metohija [14].

wind farms also. In the amendments to the Implementation Program of autonomous province of Vojvodina [24], it has been stated that the share of RES in the primary energy production of Vojvodina was 8% as the result of biomass utilization as fuel for industrial boilers. Estimations for RES potential in Vojvodina were provided in the same document: resources in geothermal power have been estimated at 85 MW or 750 GWh per year, wind energy should yield 450 GWh annually from 2011 and that should be equivalent to 250 MW of installed wind turbines, which corresponds to capacity factor of 20.5%. Small-scale hydro potential has been estimated at 90 GWh per year and biomass energy potential has been estimated at 20,500 TJ per year. The solar potential has been estimated at 5.5 kWh/m^2 per day, with large annual variations (1.6 kWh/m^2 per day – 8.1 kWh/m^2 per day). Planned wind energy capacities with the total power of 250 MW until 2012 present much higher activity in wind power sector than predicted by the national energy strategy – 45 MW of installed wind turbine power until 2012. Further information about renewable energy sector in Serbia can be found in [9–11,25–27].

3. Wind energy potential in Serbia

Renewable energy potential of Serbia is estimated to be as high as 3.83 million toe per year (44.5 TWh/per year). Most of this potential is attributed to the biomass potential (2.4 million toe per year or 62.7% of RES potential). Estimates of other renewable resources are far below biomass, but still are substantial sources compared to the overall power capacity of the state owned power plants and annual energy production. It has been estimated that small-scale hydro power plants can contribute with 0.4 million toe (10.4% of RES potential), geothermal sources have a potential of 0.2 million toe (5.2% of RES potential), solar energy has potential as high as 0.64 million toe per year (16.7% of RES potential) and wind energy potential is estimated at 0.19 million toe per year (5% of RES potential) [15].

Several studies of wind energy potential in Serbia were conducted in order to estimate wind energy potential on a large scale. The Serbian Academy of Sciences and Arts conducted a research in the new energy sources during the 1980s. One of the projects in the research dealt with the wind energy potential estimation [28]. Wind energy potential estimations for Serbia without the autonomous provinces were given in the study based on the average wind speeds collected from 48 meteorological stations elevated at 10 m. The measurements were used to extrapolate wind energy potential at 100 m above ground. The theoretical models and statistical methods were used to estimate wind speed distributions. This study has identified regions with most favorable wind speeds as eastern Serbia and regions around the Danube. Parts of the territory in the Sava basin and the left bank of the Velika Morava river have also been identified as the regions with favorable wind conditions.

The study "Possibilities for Wind Energy Utilization for Electricity Production" was ordered by the EPS in 2002 [29]. This research was based on the wind speed data from 20 meteorological stations obtained in the period from 1991 to 2000. The measurements were taken 10 m above ground. Availability of data varied

Table 2
Data availability from hydro meteorological stations for period 1991–2000 [29].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Spr	Sum	Aut	Win	Yr.
Kikinda	99.9	99.9	100.	99.2	99.7	99.9	93.2	100.	99.9	100.	99.1	99.6	99.6	97.7	99.6	99.8	99.2
Sombor	99.4	99.2	99.5	99.3	99.1	99.8	99.9	99.9	99.7	99.6	99.0	97.7	99.3	99.8	99.4	98.7	99.3
Novi Sad (RŠ)	100.	100.	99.3	100.	99.9	99.8	100.	100.	100.	100.	99.8	100.	99.7	99.9	99.9	100.	99.9
Sr. Mitrovica	89.3	84.0	79.0	86.5	94.3	96.7	96.5	94.9	92.9	94.6	84.8	93.4	86.6	96.0	90.8	89.0	90.6
Beograd	94.0	98.9	99.9	100.	100.	100.	100.	100.	100.	100.	99.6	98.5	100.	100.	99.9	97.1	99.2
V. Gradište	97.2	98.5	99.1	99.3	99.2	98.9	98.8	98.4	94.1	95.4	98.5	96.3	99.2	98.7	96.0	97.3	97.8
Loznica	99.4	99.6	99.3	98.9	95.0	99.5	99.7	99.7	99.6	99.2	99.0	98.4	97.7	99.6	99.3	99.1	98.9
Sm. Palanka	100.	99.7	99.8	99.7	99.9	99.7	100.	99.6	99.8	99.9	99.9	99.5	99.8	99.8	99.9	99.7	99.8
Negotin	97.5	97.7	98.6	98.9	99.7	99.2	99.6	99.3	99.2	99.1	95.3	95.0	99.1	99.4	97.9	96.7	98.3
Crni Vrh	15.7	20.5	15.6	27.2	27.9	28.8	29.5	30.0	47.3	47.2	26.1	24.9	23.5	29.5	40.3	20.4	28.4
Kragujevac	99.4	99.4	99.6	99.2	99.0	99.6	99.1	998	978	96.8	99.1	97.8	99.3	99.5	97.9	98.8	98.9
Ćuprija	97.1	99.7	97.1	99.8	98.9	99.2	98.5	98.6	99.0	99.7	99.1	98.9	98.6	98.8	99.3	98.6	98.8
Zlatibor	99.7	99.5	99.3	99.6	99.5	99.4	98.9	99.4	99.0	98.7	99.7	99.2	99.5	99.1	99.1	99.5	99.3
Kraljevo	89.9	99.4	96.2	97.5	89.6	76.7	69.8	69.9	80.1	79.9	82.8	80.0	94.4	72.1	80.9	89.5	84.2
Niš	89.6	89.2	89.6	89.6	89.9	89.8	89.9	89.6	89.9	89.9	89.7	89.8	89.7	89.8	89.8	89.6	89.7
Kopaonik	60.5	56.0	57.7	70.9	75.9	75.6	89.0	94.2	91.7	83.9	69.0	62.0	68.1	86.3	81.6	59.6	74.0
Sjenica	99.8	100.	100.	99.9	100.	100.	100.	99.9	100.	99.8	100.	100.	100.	99.9	99.9	99.9	99.9
Dimitrovgrad	79.9	79.3	89.9	89.9	99.7	89.6	79.7	79.7	89.4	89.4	89.9	99.2	93.2	82.9	89.6	86.3	88.0
Leskovac	100.	95.1	98.5	100.	100.	99.8	99.8	100.	100.	100.	100.	100.	99.5	99.9	100.	98.5	99.5
Vranje	87.3	87.3	90.1	89.4	89.6	99.0	100.	99.6	99.4	99.9	99.8	94.8	89.7	99.5	99.7	89.9	94.7

significantly for some stations (Table 2) and it was crucial in the result interpretation (Table 3).

The wind speed map in this study was modeled using 3D non-hydrostatic climate meso model with the resolution of 500 m × 500 m and the results were given as average annual wind speeds without silences for several time-averaged wind speeds in the range from hourly averaged wind speed to three second averaged wind speed. The results for ten minute averaged wind speeds are shown in Fig. 4 [29]. Selection of weather stations for the study and the applied model obviously resulted in the inability to better model locations in Banat, southern part of Vojvodina, which was identified in subsequent studies as one of the most favorable areas for the use of wind energy in terms of the available wind resources. According to the EPS study, annual electricity production from wind turbines could be approximately 2.2 TWh. The locations with average wind speeds above 5 m/s were taken into account. The assumptions used in this study for the annual energy yield estimation were that wind turbine had the capacity of 1.5 MW and the averaged capacity factor for the territory of Serbia was 0.2.

The Ministry of Science and Environmental Protection financed a study on Serbia's potential to utilize the wind and solar energy in 2004 [30]. The study led to the national wind and solar power maps. The methodology for the wind maps was based on synoptic climatology and was in agreement with the methodology used for European Wind Atlas [31]. Because of the inability to predict specific regional winds, the methodology was slightly readjusted in order to have a better estimation of wind resources in the region with strong periodic southeastern wind known as "Košava". The results were provided for the height of 100 m above ground. Wind speeds were measured 10 m above ground and data sample was taken for the period from 1971 to 1990 from available meteorological stations. The wind speeds were extrapolated to 100 m above ground using standard theoretical equations that took surface roughness in account. The averaged wind power density and the wind energy density were provided for July and January as the most distinctive months, as well as the map of average annual wind power density. The study has presented important data for several measurement locations in terms of the average wind speeds and wind power on a monthly basis, and monthly and yearly based wind roses. The research has identified regions with the most favorable wind resources in the eastern part of Serbia, especially around Vršac (Southern Banat), and in the Danube basin east of Belgrade and Požarevac, Fig. 5 [32].

The government of Vojvodina has recognized wind energy potential and made publicly available papers on Vojvodina's wind resource potentials. The study on evaluation of wind speeds in

Table 3
Empirical distribution hourly averaged wind speed probabilities expressed in per mill for the period 1991–2000 [29].

HMS	0	0.3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kikinda	13	13	183	260	215	144	80	46	23	12	6	3	1	1	0	0	0
Sombor	21	89	252	242	170	104	57	33	17	8	4	2	1	0	0	0	0
Novi Sad (RŠ)	1	18	227	293	184	114	66	43	25	14	8	4	2	1	0	0	0
Sr. Mitrovica	7	34	214	264	188	125	70	45	25	14	8	3	2	1	0	0	0
Beograd	27	55	304	290	158	81	41	24	12	5	2	1	0	0	0	0	0
V. Gradište	8	60	366	223	108	70	48	26	29	22	13	8	4	2	2	1	0
Loznica	148	60	491	194	67	27	9	3	1	0	0	0	0	0	0	0	0
Sm. Palanka	35	72	299	227	151	105	57	32	13	5	3	1	0	0	0	0	0
Negotin	113	177	304	146	86	75	48	32	12	5	2	0	0	0	0	0	0
Crni Vrh	32	16	68	121	151	176	153	130	80	38	17	9	4	1	0	0	0
Kragujevac	61	123	369	212	94	69	34	21	10	4	2	1	0	0	0	0	0
Ćuprija	94	117	321	172	153	81	37	15	6	3	1	0	0	0	0	0	0
Zlatibor	38	78	374	220	121	84	43	24	11	4	2	1	0	0	0	0	0
Kraljevo	80	72	389	192	102	77	44	28	12	3	1	0	0	0	0	0	0
Niš	144	148	196	252	131	74	33	15	5	2	0	0	0	0	0	0	0
Kopaonik	3	11	106	177	197	177	129	78	49	30	20	12	6	4	1	0	0
Sjenica	208	103	225	159	126	83	47	27	12	6	2	1	1	0	0	0	0
Dimitrovgrad	16	48	258	125	215	229	73	28	7	1	0	0	0	0	0	0	0
Leskovac	18	0	522	274	89	58	25	10	3	1	0	0	0	0	0	0	0
Vranje	25	124	202	98	232	140	115	48	12	3	1	0	0	0	0	0	0

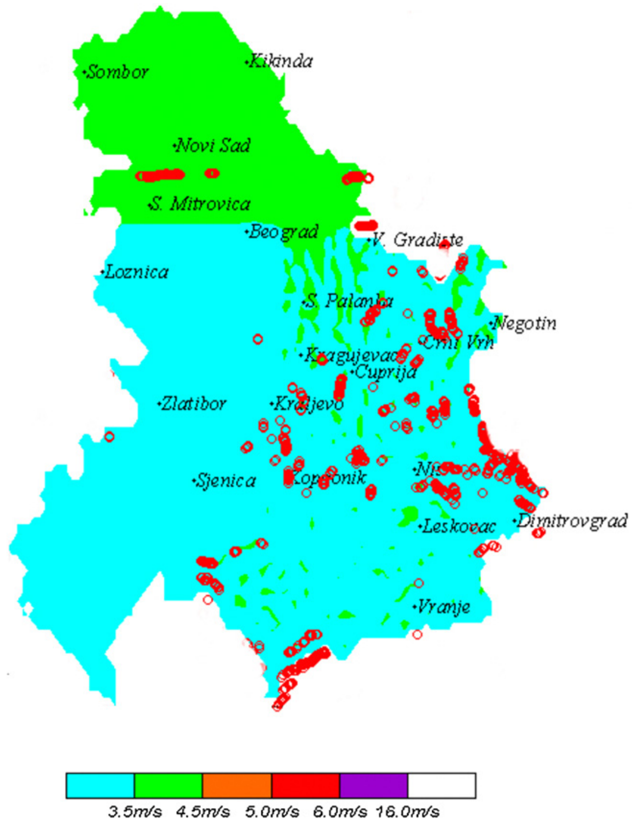


Fig. 4. Wind speed map in Serbia showing the locations with ten-minute averaged wind speeds between 5 m/s and 6 m/s at 50 m above ground [29].

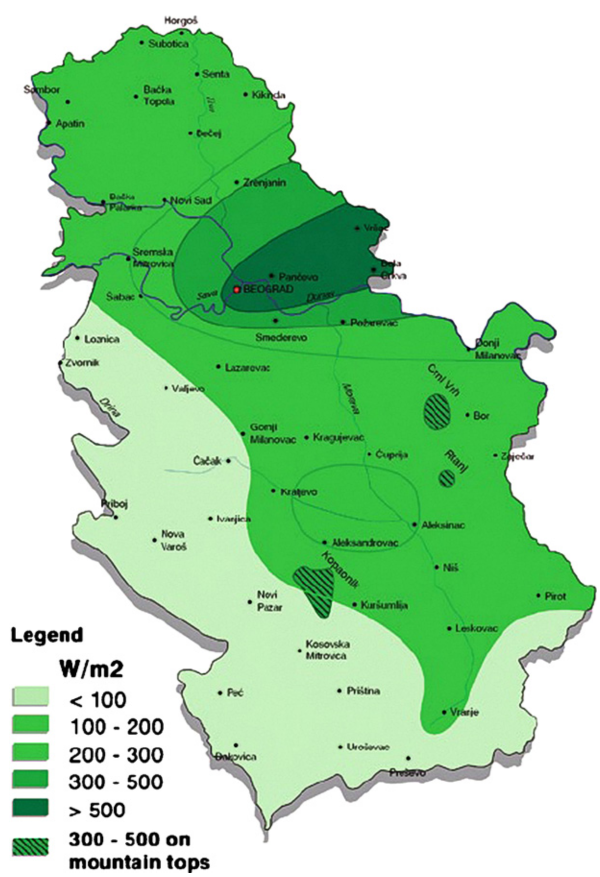


Fig. 5. Map of average wind power density in W/m^2 at 100 m above ground level for heating period (October–April) from 1961 to 1990. [32].

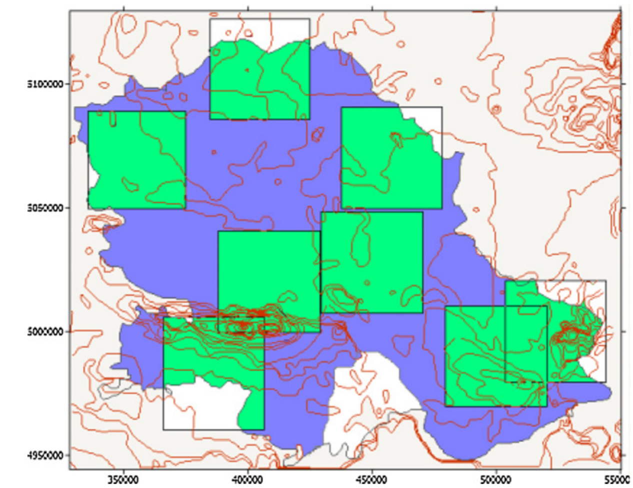


Fig. 6. Meteorological stations used for the wind potential assessment in Vojvodina [34].

the selected locations was published in 2005 by the University of Novi Sad and the Meteorological Observatory of Novi Sad [33]. The subject of the study was to investigate the methods for wind speed evaluation in terms of the existing data and dependence of wind speed on the elevation above ground and surface roughness. The results were obtained (regarding the wind speed data) from three meteorological stations – Rimski Šančevi, Banatski Karlovci and Kikinda in which measurements were conducted in 1997.

The Secretariat for Energy and Mineral Resources of Vojvodina financed a research in 2007, which resulted in the study “Wind Atlas of AP Vojvodina” [34]. Wind energy potential was estimated using the data from eight meteorological stations based in Vojvodina. The data sample was taken for the period 2001–2007, except for the station Banatski Karlovac where unavailable data for 2001 and 2002 were interpolated using the data from Vršac and Zrenjanin. Hourly averaged wind speeds were processed, that gave, according to the study, 6–7% lower wind power density compared to the standard ten-minute averaged wind speeds. The study was based on the standard methodology used for European Wind Atlas, and the wind maps were developed using WaSP software with the bottom-up approach [34]. The wind speed measurements were taken at 10 m above the ground. All necessary corrections were taken into account, both regarding the local environment of meteorological stations (mini map of terrain with roughness) and the orography 20 km around the stations. Wind speed and wind power density maps were calculated for an area of 40 km by 40 km around each meteorological station (Fig. 6). This data have been interpolated for the territory of Vojvodina and used for drawing up the wind speed and wind power density maps for 10 m, 25 m, 50 m, 100 m and 200 m above ground. The wind power density in Vojvodina at 50 m above ground is shown in Fig. 7 [34]. The study provided the most comprehensive data on the wind potential for the territory of Vojvodina. In the appendix to the study, the following were provided: climatology of measured wind speeds at 10 m above ground, wind atlas extrapolated for 50 m above ground, detailed wind speed and average wind power density maps and summary of the wind atlas extrapolated for the wind speeds 50 m above ground for all stations [35]. Authors of the study identified southern and south-eastern Banat as the most favorable areas for the construction of wind farms. In the conclusions of the study, authors emphasized the necessary steps that need to be taken in order to get more accurate wind maps, such as larger data sample for the periods longer than ten years, more accurate orography of the Vojvodina territory,

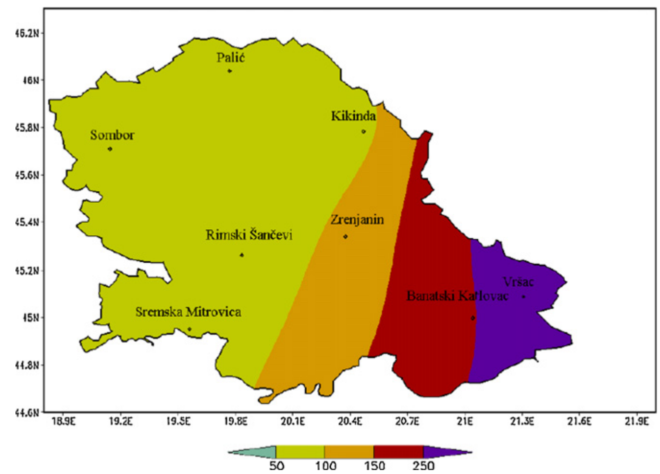


Fig. 7. Average annual density of wind power in Vojvodina at 50 m above ground level in W/m^2 [34].

data from meteorological stations located in the border areas and specific purpose wind masts.

Wind energy potential in Vojvodina has also been identified by Đurišić et al. [36]. The map of wind power density, Fig. 8, was made according to the wind velocity measurements taken at six meteorological stations in the Vojvodina Region and three bordering stations situated in Croatia, Hungary and Romania. The standard methodology from the European Wind Atlas was employed. The results were partly verified by the wind velocity measurements taken on the anemometric mast, 40 m high, located in the vicinity of the meteorological station Banatski Karlovac.

In addition, the results for the sub-region of Deliblatska Peščara in Banat were presented. Detailed orography, roughness and obstacle models were used for the map of the wind potential of the sub-region. Several micro locations were identified with the average wind speeds higher than 6.2 m/s at 50 m above ground.

4. Legislative framework and technical regulations for wind power sector in Serbia (development)

Planned wind energy capacities that were defined in the Energy Sector Development Strategy Implementation Program of the Republic Serbia and later amendments [23,24,37] have been delayed. According to the original Program, 10 MW wind turbines should have been erected in 2009 and 2010. None of the wind power capacities have been installed until 2010. Moreover, plans for the construction of all the other RES capacities have not been fulfilled. The reasons for this could be found in ambiguous and incomplete regulations concerning the construction of RES capacities, which led to a slow administration processing of considerable application documentation for the construction permits, and consequently a lack of private investments. Undefined support mechanisms until 2009 and general lack of political will could be regarded as some of the key obstacles for the realization of RES goals defined in official documents [38]. In this section, the establishment of valid legislative framework and institutions responsible for the RES development in Serbia was reviewed in order to identify possible issues that arise from it when applied to wind power sector.

Reform of energy sector in Serbia began in 2004 by adopting the Energy Law [39]. Developed regulatory framework in period 2004–2010 has been directed towards adoption of the EU rules and regulations in power sector. In August 2011 new Energy Law has been adopted by National Assembly [40], which should reduce some of the previously identified regulative obstacles. The government has signed a Memorandum on creating a regional electric power market in the Southeastern Europe and The Energy Community Treaty [41–43] and undertook the obligation of thorough energy sector reforms. The same process has been initiated in the neighboring countries which have been facing similar difficulties and obstacles in the reform path [44,45].

The Energy Law defines national energy policy goals, energy market, conditions for continuous and high quality energy supply to the buyers, conditions for safe, reliable and efficient energy production, management of transmission, transport and distribution of energy. The Law also regulates the terms and conditions for energy related activities, the conditions for energy efficiency and environmental safety in energy activities.

The former Energy Law laid down a framework for restructuring the vertically integrated Serbian Electric Power Industry (EPS). The government issued a decision on founding two public enterprises in 2005 that were mentioned in Section 2, namely EPS and EMS [46,47]. Both of them are 100% state owned.

EPS main activities are coal production, electricity generation and distribution and distribution system management. Under the EPS, there are six public enterprises mostly dealing in coal and electric power generation and five public enterprises for the electric

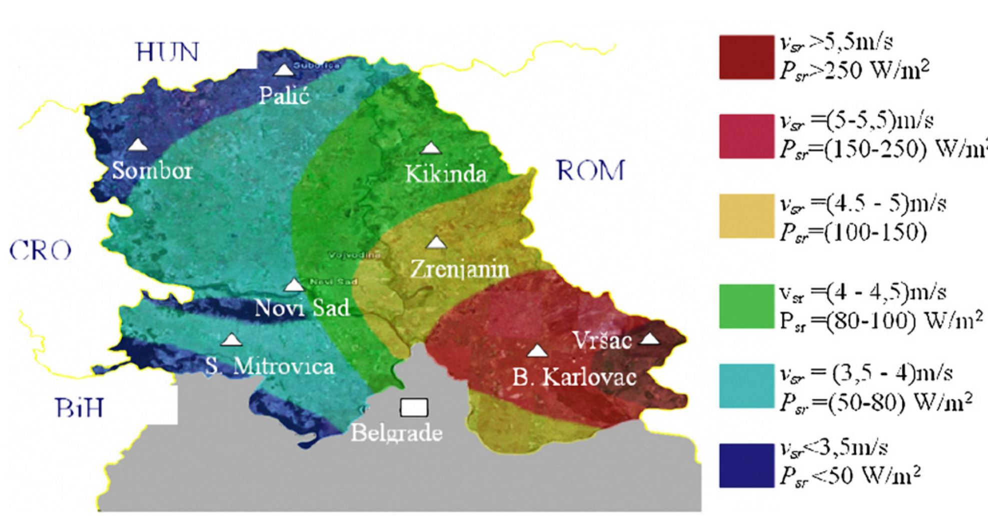


Fig. 8. Average annual density of wind power in Vojvodina at 50 m above ground level [36].

power distribution. As stipulated by the Energy Law, each electric power distribution enterprise has an obligation to define terms and regulations for the use of distributive system. For example, on the territory of enterprise "Elektrodistribucija Beograd" the company declared such regulations in 2010 [48]. Normative and technical terms and conditions for small-scale power plants up to 10 MW are defined in these documents. There are specific requirements for wind power equipment regarding basic technical requirements for grid connection.

EMS is a public enterprise for electric power transmission and management of the transmission grid and the electricity market. According to the Energy Law, this enterprise is transmission system operator and is responsible for the determination of technical conditions for connection on transmission grid. System operators are obliged to treat all energy generators as equal. EMS is also an electricity market operator. Electricity buying and selling may occur directly among the defined energy entities involved in energy-related activities or on organized electricity market. Electricity producers, suppliers of tariff buyers, electricity traders and qualified electricity buyers may participate in organized electricity market. Electricity market has still not been activated. The reasons can be found in low electricity price provided by the EPS, as this is still a social category that has not been tackled by the government in an appropriate manner.

Two government independent regulatory institutions have been formed as the result of the Energy Law: The Energy Agency of the Republic Serbia and The Serbian Energy Efficiency Agency. The Energy Agency of the Republic Serbia is an independent regulatory body the purpose of which is to promote energy market and to provide fair energy market environment, to track implementation of the regulations for energy systems, to coordinate various activities of the entities dealing with energy in order to maintain a continuous electricity supply to customers and protection of their rights. The activities of the Energy Agency that are of interest to wind energy sector and RES energy sector development in general are: determination of the tariff systems for calculating electricity prices for the tariff customers, determination of the methodology for calculating electricity prices base on the tariff system, determination of the criteria and methodology for transmission and distributive grid connection costs, issuing and withdrawing of energy licenses, decisions on appeals from energy entities for grid access that was denied by the system operators, determination of minimum annual electricity consumption for qualified buyers, fulfillment of necessary conditions for the status of qualified buyer and register management of qualified buyers.

The Energy Efficiency Agency is responsible for the improvement of conditions and measures for rational and efficient use of energy and fuels, as well as an increases in energy efficiency in all the segments of energy utilization. One of the main activities of this agency is the promotion of RES utilization and environmental protection.

Renewable energy sources were defined in the former and currently valid Energy Law, as well as the category of privileged energy producers. Producers that use RES or waste, producers who produce electricity in small-scale power plants (up to 10 MW) and producers with the combined production of electric energy and heat are the privileged energy producers. They will be prioritized in the regulated internal energy market. Also, they are entitled to subsidies and tax incentives. The subsidies for RES were to be regulated by the government. Governmental decrees that defined incentives for RES utilization were declared as late as 2009 [49,50]. The adopted incentives are feed-in tariffs, which should provide financial prerequisites for wind energy sector development [51,52]. According to the adopted feed-in tariffs, incentives for electric energy generated by wind turbines is limited to 450 MW. Privileged producers also have the right to use feed-in tariffs for wind turbines if the power of wind farm is not greater than 10% of the electricity generation capacities constructed by the EPS within the period the decree is effective, i.e. within the period of twelve years from the date of decree adoption. The same time frame is adopted as the feed-in tariffs validity period. Electricity generators that use the wind power are regarded as privileged producers without the limit for output power of wind farm.

The energy permit is needed for the construction of power plants larger than 1 MW. According to the valid Energy Law, it is issued by the Minister of Mining and Energy for a period of three years, with the possibility of validity period extension which cannot be longer than one year. Another document, energy license should be obtained in order to start energy production in a power plant that has a capacity larger than 1 MW and is intended for the public grid connection. The energy license is issued by the Energy Agency for a period not longer than thirty years for electricity producers with the possibility of extension. General conditions for obtaining the energy license were defined in the Energy Law. Small-scale power plants (up to 10 MW) may be connected to distribution system and have the right to sell their electricity over the distribution grid.

As the Energy Law provided general conditions and terms for RES utilization, a set of strategic documents and technical regulations had to be adopted. The government proposed The Energy Sector Development Strategy of the Republic of Serbia by 2015 [15] according to the former Energy Law, which was adopted by the National Assembly in 2005. Subsequent Energy Sector Development Strategy Implementation Program of the Republic Serbia by 2012 [23] was adopted in 2007. The Autonomous Province of Vojvodina made its own supplemental strategy and implementation program that is in accordance with the national documents. Some of the best sites for the wind energy utilization are located in Vojvodina. State administration amended Implementation Program with the revised goals regarding the planned RES capacities in 2009 [24,37]. In these documents it was stated that there was a need for decentralization of electricity and heat generation, which can be achieved by constructing the power plants with the capacities below 10 MW in order to meet the energy demand in the local market and a possible dispatch of surplus energy to the local electric network that is a part of the national electric energy system. The experience of some of the most developed countries suggests that involvement of small local investors and households is beneficial for the wind energy sector development, which can have an outstanding influence in the initial phase of sector's development. According to several authors, 90% of wind turbines in Germany are privately owned and approximately 200,000 individuals own shares in cooperatives, 150,000 households in Denmark owned or held shares in wind turbines by 2001 [53–55]. One of the obstacles for initiating the RES (wind) energy market, which has been identified in the national Implementation Program of Energy Strategy, is insufficient public support and awareness of the benefits from RES utilization, which could be increased by encouraging local involvement in the wind energy market. Other barriers for RES, i.e. wind energy market development, that were identified in Implementation Program include: regulatory framework anomalies, complicated administrative procedure, low price of electric power and disparity of fuel prices.

By adoption of the decree on feed-in tariffs for RES [50] and the decree on privileged energy producers [49], initial steps to overcome obstacles regarding insufficient financial incentives for the wind power and RES utilization in general, were made in 2009 [56]. According to the feed-in tariff decree, defined price for the electricity produced by wind turbines is 9.5 Euro cents per kWh.

In order to fulfill the requirements for the wind power plant commissioning and dispatching of generated electricity to the public electrical grid owned by the EMS, a wind power plant has to be planned, designed, constructed and operated in accordance with

the Energy Law, the Law on Planning and Construction [57], set of laws on environmental protection [58–60] and technical regulations on the distribution and transmission networks. Power plant must be constructed in agreement with the Decree on stimulating measures for electricity generation utilizing RES and by combined electricity and heat generation [50] and the Decree on conditions for obtaining the privileged electricity generator status and the criteria for evaluating those conditions in order to acquire the status of a privileged electricity producer [49].

In order to construct a wind farm it is necessary to obtain the following: energy permit, location permit, construction permit, water permit and operating permit [61]. As none of the wind farm projects larger than 1 MW have been completed by the beginning of 2011, there has not been established the standard practical road map for getting all the necessary documents in order to attain all the permits and begin with the actual electricity generation, which would be helpful both for the interested investors and different levels of national and local authorities. The reasons for the present state, beside the current legislative framework and social issues, can be found in an inadequate training of the staff that would be implementing the adopted regulations, and insufficient level of information provided to investors, designers and constructors of wind power plants. Owing to an undeniable interest of foreign and domestic investors in the RES sector development, the EPS issued a document with a short list of the necessary steps that investors need to take for the commissioning of the electricity generation facility [62].

The energy permit is obtained for the construction and reconstruction of wind power plants with the installed capacity larger than 1 MW from the Ministry of Mining and Energy, Table 4. The criteria for issuing the energy permit include conditions necessary for the safe and undisturbed energy system operation, conditions for location and land utilization, conditions regarding environmental protection, health and safety precautions for people and property, energy efficiency level and conditions related to the level of technical equipment and financial solvency of the applicant in order to complete the facility construction. If a wind farm is intended for connection to the transmission network, an opinion about the conditions and possibilities for connection must be issued by the EMS in order to obtain the energy permit. Consent by the Electric Power Distribution Enterprise must be obtained for the connection, if the wind farm grid connection is achieved through a distributive network. One of the criteria for obtaining the energy permit, according to the Energy Law, are the conditions for the environmental protection. Application for the energy permit has to include the analysis of possible modes of environmental protection during the construction and operation of a wind farm.

Location permit, construction permit and operating permit are issued by the local government except if the wind farm is built in a national park or within the boundaries of a protected natural resource of outstanding significance, if the wind farm capacity exceeds 10 MW or the wind turbine height exceeds 50 m. In the above exceptions issuance of the permits is the responsibility of the Ministry of Environment and Spatial Planning (MESP) or Vojvodina's Provincial secretariat for environmental protection and sustainable development (PSEPSD).

The procedure for obtaining location permit includes submission of the evidence of the right to property, a general design of the wind farm and the approval with respect to air traffic safety. Furthermore, in order to acquire the location permit, different technical requirements have to be met, such as the requirements for the grid connection from the competent electricity distribution company or the EMS and water requirements from the Ministry of Agriculture, Forestry and Water Management or an equivalent institution at the level of a province. It is specified in the relevant regulations that in order to obtain the location permit, pre-feasibility study for power plants larger than 10 MW has to be prepared if there are not any written plans from the competent authority upon which the location permit can be issued (local spatial plan). Investors can be faced with the obstacles and delay of the project if the local municipality has not defined all the necessary conditions for implementation of spatial and urbanism plans. Similar problems have been identified in some developed countries, where local municipal institutions and officials have broader authorities regarding implementation of the national RES strategies and plans [63]. On the other hand, there are examples of successful avoidance of such problems by more vertically controlled implementation of national RES goals [64].

The steps prior application for a construction permit also include a (prepared) preliminary design of wind farm and the environmental impact assessment study approved by the competent authority. According to the Law on Planning and Construction, evaluation of the wind farm impact on the environment is a part of the initial planning phase of the project [65] and has to be approved by the relevant institutions in order for the construction license to be obtained.

According to the Law on Environmental Protection [60], the Law on Environmental Impact Assessment [58], the Decree on determination of Project list for which impact assessment is obligatory and Project list for which environmental impact assessment may be required [66], impact assessment on the environment for the power plants with the installed power capacity exceeding 50 MW is necessary and obligatory in order for the construction permit to be obtained. However, according to List 2 – the list of projects for which the impact assessment may be required, if the wind farm is larger than 10 MW, impact assessment study is obligatory [67]. It is necessary to prepare an assessment of the impact on birds in the Environmental Impact Assessment Study. According to the Nature Protection Law [68], the investor shall perform all construction and other activities in compliance with the nature protection measures that were stated in the relevant plans and in accordance with the approved design documents in order to reduce the impact on nature. The competent authority shall issue an approval for the study only if the Bureau for Nature Protection determines that the construction of wind power plant will not have a significant impact on the environment.

Prior to the construction, investor has to obtain the water approval according to the Law on Waters [69] that is in concordance with the water requirements issued during obtaining documents for the location permit. The competent authority to make a decision on the water approval is the Ministry of Agriculture, Forestry and Water Management or the equivalent secretariat of a province.

After the construction of the facility, it is necessary to perform technical inspection of the completed facility by the competent authority (depending on the wind farm installed power). Revision of the main design documents in terms of unpredictable and unavoidable changes in the design during the construction of a wind farm is needed as well in order to complete the as-built project documentation. These documents and the water permit issued by the Ministry of Agriculture, Forestry and Water Management in accordance with the previous water approval are the necessary documents for obtaining the operating permit. Technical regulations and standards regarding wind turbines are still not adopted on the national level, which can have a substantial influence on the process of acquiring the operating permit. However, the National Institute for Standardization announced the plans to adopt the technical standards in 2011 that include the relevant set of standards for wind turbines.

In addition to completing the mandatory procedure for obtaining the permits for construction and operation of a wind farm, investors are faced with the procedure of obtaining the license to electricity generation. The Law on Public Enterprises and

Table 4
Competent authorities for issuing of relevant documents for wind farm construction and operation.

Power plant capacity [MW]	Energy permit	Construction permit	Privileged generator status approval	Energy license
Less than 1	Not required	Municipality	Ministry of Energy and Mining Contract with EPS	Not required
1–10	Ministry of Energy and Mining	Municipality	Ministry of Energy and Mining Contract with EPS	Energy Agency
More than 10	Ministry of Energy and Mining	Ministry of Environment and Spatial Planning	Ministry of Energy and Mining Contract with EPS	Energy Agency

Performing Activities of Public Interest [70] regulates electricity generation as the activity of public interest. It states that public enterprises or another company that obtained a permit from the competent authority can perform an activity of public interest. According to these regulations, any third party may be the electricity producer if it obtains an approval from the government for conducting the electricity production as an activity of public interest. Conditions for such an approval are adequate technical prerequisites (ownership or right to use wind farm), staff capacity with the necessary qualifications, implementation of safety measures and implementation of the prescribed methods for protection and improvement of the environment.

The Energy Agency of the Republic of Serbia is the responsible regulatory body for issuing the energy licenses. According to the regulations, energy license shall be issued to the energy entity for energy-related activities, one of which is electricity generation. Energy license is not obligatory for the power plants with the capacity lower than 1 MW or in case of electricity production for own purposes. It is issued for a period of thirty years. Detailed requirements for the energy license are given in by-laws [71–73].

In former Energy law an approval by the government for conducting the activities of public interest was needed for all wind farms regardless of the capacity, which is not necessary for the issuance of the energy license. According to the new Energy law this issue should be solved. It should be noted that in valid Energy law the “green certificates” have been defined, as well as the responsible authority for the issuance of “green certificates”.

Connection of a wind farm to the grid (distributive or transmission) is achieved upon approval by the relevant energy entity whose system will be used for the grid connection (currently there are two options, one of the companies for electricity distribution under the EPS or the EMS if connection is on the transmission grid) with consent from the system operator (EMS). The connection is approved after the inspection of the wind farm and fulfillment of all the requirements prescribed by the relevant laws and by-laws. More precisely, electrical equipment in a wind farm has to fulfill the requirements prescribed by the EMS and the EPS [48,74,75]. These requirements are repeatedly referenced in the course of the procedure of acquiring the permits for wind farm construction and operation.

Application for acquiring the privileged electricity producer status is submitted to the Ministry of Mining and Energy with the following enclosed: energy license, as-built design, approval on the grid connection, operating license and data on the person responsible for the power plant. Buyer of electric energy shall buy electricity from the privileged producer at prescribed prices (feed-in tariffs). Relations between buyer and privileged producer are regulated by a contract for a period of twelve years. Currently, the only eligible buyer of electric power is the EPS. The model of the contract has been submitted to the Ministry of Mining and Energy to be approved by the EPS. The contract between buyer and privileged producer proposed by the EPS defines terms and conditions for dispatching energy to the electrical grid, measurement and price of the delivered energy, force majeure, authorized persons for activities based on the contract and conditions for contract termination.

The Serbian Wind Energy Association (SEWEA) has proposed amendments to the draft of the new Energy Law that was subject to a public debate at the beginning of February 2011 by the Ministry of Mining and Energy [76]. SEWEA has proposed the model of a privileged producer electric power purchase agreement to be included in the appendix to the new Energy Law. This association identified the shortcomings of the current legislative and urged for modifications that would be beneficial to the RES sector development in general. According to the wind energy professionals, current regulatory framework and adopted changes by the government are insufficient for the development of wind energy sector in terms of large-scale wind farms.

5. Current developments of the wind energy sector

Academic researches regarding wind energy have been conducted at local universities and research institutes for more than twenty years. In addition to the mentioned wind potential explorations, researches have been directed towards acquiring a specific technical knowledge needed for designing, manufacturing, erecting and testing of wind turbines and wind farms. Several independent research teams have been working in different areas of wind energy related researches including the development of models for estimation of wind energy yield, rotor flows, wind farm layout optimization, design of mechanical and electrical components, testing of wind energy related parts and equipment etc. Until recently, there was not a strong commercial justification of such researches despite the fact that the government financially supported majority of them. These researches mainly remained commercially unused due to the high risks regarding their further investment return and the existence of mature technologies from abroad. However, accumulated research experience has been used in recently initiated wind energy related courses at several universities, which will be useful in order to meet the growing need for wind energy professionals and to provide more such specialized courses, which were previously lacking [77].

An increased interest in wind energy has been registered in Serbia during the last decade. Sufficient, recently documented, wind energy potential is a good starting point for attracting interested domestic and foreign investors to build and operate wind farms. During the first half of the last decade, after the government adopted the national strategic documents regarding energy and undertook the obligations stipulated in the Energy Community Treaty [42], substantial number of small size companies interested in the wind power sector and RES in general has emerged. This number has been increasing since then, although the companies have been facing large number of administrative and technical difficulties, which led some of them to bankruptcy.

The Energy Efficiency Agency has been making efforts in order to promote RES and wind energy. One of the initiatives was directed towards strengthening the Centre for RES in the Energy Efficiency Agency, which was financially supported by the Government of Spain [78]. The project was directed towards analyzing the possibilities of using wind energy for electricity production in Serbia, Fig. 9. It was planned to conduct high quality local wind speed

Table 5
Wind speed measurements in research supported by Government of Spain and Serbian Energy Efficiency Agency [78].

Site	Mean wind speed at 50 m [m/s]		Extrapolation at 80 m [m/s]		Measurements availability [%]	
	6 months	12 months	6 months	12 months	6 months	12 months
Veliko Gradište	3.61	3.50	3.82	3.71	99.7	99.0
Negotin	5.24	5.77	5.55	6.10	86.4	92.4
Titel	4.68	4.72	4.95	4.99	97.8	98.1



Fig. 9. Locations for wind speed measurements supported by Energy Efficiency Agency [79].

measurements on several locations and to prepare a feasibility study for the most favorable location. The project initiated technology transfer from Spanish partners to Serbian companies and the Energy Efficiency Agency in terms of quality wind energy assessments and wind farm feasibility studies. The Ministry of Mining and Energy and the local governments supported the project. The site was selected based on the criteria such as wind potential, elevation, orography, existence of access roads, acquisition of necessary permits and proximity of electricity transmission lines. The wind speed measurements were initiated in 2007. Among the three tested locations, Negotin was selected as the most favorable (Table 5). The completed study has demonstrated the necessary steps for the preparatory activities for the construction of large wind farms connected to the transmission grid in Serbia. Total power of the planned wind farm would account for 45 MW with 112.8 GWh expected annual energy production. The authors expected wind farm capacity factor to be as high as 28.6% and investment pay back period between 7 and 9 years.

The Institute for Multidisciplinary Research has been participating in research SEEWIND – Wind Energy in Southeastern Europe under the 6th Framework Programme of the European Commission [80]. This research has been directed towards investigation of different locations in Southeastern Europe in mountainous and complex structure terrain with specific local winds, and examination of more efficient and reliable operation of large-scale wind turbines under these conditions. One of the three locations that were subjects of the research was Vlasina, in Southern Serbia, Surdulica Municipality. The other two were located in Croatia (Rudine) and Bosnia and Herzegovina (Podvelez). The main goals of the research include improvement of the methods for wind speed measurement and simulation in complex terrain, energy yield prediction, testing of large-scale wind turbines under extreme conditions, higher efficiency and reliability of wind turbines and improvement of building codes and standards for wind turbine in the West Balkans. The local enterprise was selected to install and operate a wind turbine that would be the part of the 93 MW Vlasina wind farm planned on the same location [81]. In addition to research involvement in SEEWIND, the Institute for

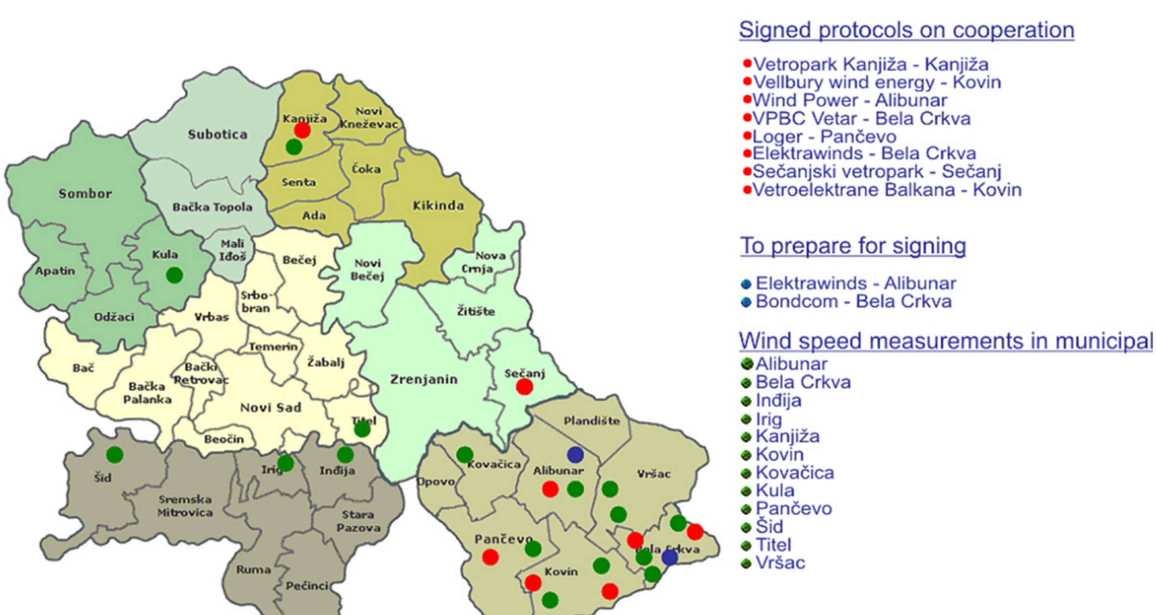


Fig. 10. Wind energy related activities in Vojvodina [83].

Table 6
Issued energy permits for wind farms in Serbia [91].

Company	Energy permit no.	Date of issuance	Date of expiration	Wind farm name and power	Location
PD DOO VPBC Vetar	312-01-00532/2008-02	30.12.2008.	09.01.2011.	Wind farm "Vračev gaj", 187.5 MW	Bela Crkva
PD Wellbury Wind Energy DOO Beograd	312-01-00085/2009-02	24.04.2009.	14.05.2011.	Wind farm "Bavaništansko polje", 188 MW	Kovin
PD Windtim doo Beograd	312-01-00390/2009-02	02.08.2009.	19.08.2011.	Wind farm "Šušara", 60 MW	Vršac
PD Energowind DOO Vršac	312-01-00588/2009-02	07.10.2009.	16.10.2011.	Wind farm "Vršac-Alibunar-Plandište", 400 MW	Vršac
PD Vetroelektrane Balkana DOO Beograd	312-01-00597/2009-02	16.10.2009.	30.10.2011.	Wind farm "Čibuk", 300 MW	Kovin
ZAD MK-Fintel Wind AD Beograd	312-01-00034/2010-02	15.04.2010.	24.04.2012.	Wind farm "Košava", 117 MW	Vršac
ZAD MK-Fintel Wind AD Beograd	312-01-00472/2009-12	02.06.2010.	02.06.2012.	Wind farm "La Piccolina", 5 MW	Vršac
Ivicom Energy DOO, Žagubica	312-01-1085/2009-02	25.06.2010.	25.06.2012.	Wind farm "Krivača", 112.8 MW	Golubac and Kučevo
Vetropark Inđija doo, Inđija	312-02-190/2010-02	06.07.2010.	06.07.2012.	Wind farm "Inđija", 20 MW	Inđija

Multidisciplinary Research has been conducting several researches of the local wind energy potential in Eastern Serbia including locations in Krnjevo, Salaš and Dimitrovgrad [82]. Furthermore, several companies with the support of research organizations have conducted wind speed measurement campaigns. On the territory of Vojvodina there were 16 wind speed measurement campaigns for specific wind farm purposes identified in addition to eight signed cooperation protocols regarding wind farm construction, Fig. 10 [83].

As part of the majority of initiated wind farm projects, necessary assessment of available wind on the sites was conducted. Two measurement stations have been used for wind resource assessment on the location of Šušara in south-eastern Banat. Combined with computational fluid dynamics simulations the obtained data was used to estimate the local wind energy potential for the purpose of planned wind farm "Šušara" [84]. On location Čibuk custom 40 m anemometer mast was installed [85], as well as on location in Jabučki Rit where 60 m mast was raised for micro location assessment [86]. Wind energy assessment in mountainous regions of Serbia based on data from meteorological stations and WaSP software is available in [87]. Mesoscale wind modeling was used to obtain preliminary wind resource assessment for regions of Vlasina and Braničevo, mountains: Veliki Jastrebac, Kopaonik, Stara Planina, Miroč and sites Tupižnica and Rtanj. Possibilities of wind energy utilization in mountain areas (Vlasina region) were also investigated in research described in the paper [88]. In addition to computational fluid dynamics analyses of the wind resource, two measuring mast were erected at locations Golemi Vrh and Stolovi that were used for subsequent wind potential assessment. Similary, within the project "Study of technical and economical potential of electricity production by wind-generators on micro-site TE Kostolac" [89] financed by the government, optimum locations for installing wind mast have been analyzed for selected micro location [90].

The administrative procedure for fulfilling all preconditions for initiation of the project can be delayed if municipalities determine that certain documents are missing, such as the local spatial plans for determining the purpose of specific locations. Subsequent procedure regarding detailed spatial planning of a wind farm is needed.

Energy permits issued until the end of 2010 are shown in Table 6 [91]. The Ministry of Mining and Energy has issued the energy permits for wind farms with the total capacity larger than 1390 MW. The majority of capacities with energy permits are based in Vojvodina (1277.5 MW). More than 1250 MW have been planned in Banat, which has been identified as the most favorable area for wind farm construction. The projects in the Municipality of Vršac have been facing environmental issues. It must be emphasized that, according to Vojvodina's Institute for Nature Protection, this area is in the migratory path of several rare bird species [92].

6. Conclusions

Limited availability of the fossil energy sources, environment and climate issues, the anticipated growth in energy consumption and the possibility to reduce energy dependence impose the need to utilize renewable energy sources and to increase energy efficiency. Implementation of new technologies in the exploitation of renewable energy sources is a necessity. The government of Serbia has made strategic decisions regarding energy portfolio of the country until 2015. These documents entail a strategic commitment to developing renewable energy sources in the future. According to the same documents, it has been planned to support the development of wind energy sector. Current energy policy has been developed according to the policies in EU countries. Serbia has signed the South East Energy Community Treaty and was obliged by

it to implement reforms in the energy and environmental sector in accordance with the EU policies. Reforms in the energy sector have been initiated, and majority of relevant laws have been adopted. The framework for RES, and the development of wind energy sector, has been laid down. However, considerable amount of work remains in terms of specific administrative and technical regulations that are needed in order to make the market conditions efficient and attractive for interested investors.

The wind energy potential of Serbia estimated by the officials and independent institutions can be considered sufficient for commercial exploitation at present level of the wind energy technologies. According to the Energy Sector Development Strategy adopted by the government, Serbia has a potential to produce 2209 GWh of electricity from wind energy, which presented more than 5% of electrical energy production in Serbia in 2010. In the optimistic scenarios made by some authors, electricity production from available wind power can be higher than official estimations. However, the limiting factor for the wind energy sector development is the capacity of the national electricity grid. According to the present state of the electrical grid, conservative estimation is that 450 MW of installed wind turbines would not have a substantial effect on the grid stability.

Current level of the legislative framework regarding wind energy sector development is insufficient for encouragement of entrepreneurs to get into wind energy endeavors. Government action is needed in order to further promote the RES use. Strong government support, both on the national and local (municipality) level is needed for the development of wind energy sector. Large-scale wind farm projects have been undertaken by several investors, but none of them have been completed until the end of 2010. Administrative, financial, technical and environmental obstacles appeared. These can refer to incomplete regulations, untrained authorities for issuance of the needed project (requirements and) permits and uninformed investors. Projects that have been validated through the energy permit issuance are mostly larger than 50 MW. In most cases these wind farms would be constructed in several phases. The government officials should have developed efficient regulatory framework in order to direct investments toward smaller-scale "megawatt" projects in order to gain the necessary experience and also to avoid environmental, technical and administrative constraints in a reasonable time frame. These types of projects should be feasible in a shorter time frame than the large-scale projects initiated in last three years. The initiative to organize local municipalities in order to actively participate in the wind sector development is needed. Experience from the most advanced countries in terms of wind energy utilization shows that involvement of local municipalities can be beneficial to the sector development. Smaller-scale wind farm projects developed in order to partially support local energy demand could substantially contribute to the wind energy promotion.

Wind energy sector in Serbia is in its initial phase of development. Base regulatory framework was set in 2009, concerning the rights and obligations of private electricity producers and privileged producers eligibility criteria. The feed-in tariffs were adopted in 2009, with 9.5 Euro cent per kWh incentive for electricity produced using wind energy. However, several obstacles can be identified for a swift wind energy sector development. Legal procedure for acquiring all the necessary permits can be unjustifiably long. Authorities and regulatory bodies could improve this process if the activities were coordinated in order to acquire the map of suitable locations for wind farm construction. Currently, there are no technical standards concerning wind turbines adopted by the National Institute for Standardization. This issue should be resolved as the Institute for Standardization announced adoption of EN 61400 series of standards during 2011. Technical issues regarding grid connection could emerge for large-scale wind farms that remain to be solved by the relevant distributive or transmission system operator and investor.

It can be concluded that the emerging wind power sector in Serbia will develop in the near future despite the difficulties faced by the investors, regulatory bodies and other shareholders, in the course of the past several years. There is an urgent need of a broader transfer of specific knowledge and technology related to wind farms and wind turbines in order to speed up the current wind sector development. Nevertheless, activities on promotion and raising of public awareness regarding the wind power utilization are necessary.

Acknowledgements

This paper is a contribution to the research TR 35035 funded by Ministry of Science and Technological Development of Serbia. The authors would like to express particular gratitude to Olivera Ristanović-Santrač for proof reading of the paper.

References

[1] Labriet M, Cabal H, Lechon Y, Giannakidis G, Kanudia A. The implementation of the EU renewable directive in Spain. Strategies and challenges. Energy Policy 2010;38(5):2272–81.
[2] Mostafaeipour A. Productivity and development issues of global wind turbine industry. Renew Sustain Energy Rev 2010;14(3):1048–58.
[3] www.ewea.org, last accessed February 2011.
[4] Saidur R, Islam MR, Rahim NA, Solangi KH. A review on global wind energy policy. Renew Sustain Energy Rev 2010;14(7):1744–62.
[5] World wind energy report 2009, World Wind Energy Association WWEA 2010.
[6] Zhao ZY, Hu J, Zuo J. Performance of wind power industry development in China: a diamond model study. Renew Energy 2009;34(12):2883–91.
[7] Jacobsson S, Bergek A, Finon D, Lauber V, Mitchell C, Toke D, Verbruggen A. EU renewable energy support policy: faith or facts? Energy Policy 2009;37(6):2143–6.
[8] Mikičić D, Radičević B, Đurišić Ž. Wind energy potential in the world and in Serbia and Montenegro. Facta Universitatis (Niš). Ser Elec Energy 2006;19:47–61.
[9] Karakosta C, et al. Review and analysis of renewable energy perspectives in Serbia. Int J Energy Environ 2011;2(1):71–84.
[10] Schneider DR, et al. Mapping the potential for decentralized energy generation based on RES in Western Balkans. Thermal Sci 2007;11(3):7–26.
[11] KEMA Consulting GmbH. Renewable Energy Sector Study Serbia; 2011.
[12] Jednak S, Kragulj D, Bulajic M, Pittman R. Electricity reform in Serbia. Utilities Policy 2009;17(1):125–33.
[13] Annual report 2009, Electric Power Industry of Serbia; 2010.
[14] Technical yearbook. Electric Power Industry of Serbia; 2010.
[15] Government of the Republic of Serbia, Ministry of Mining and Energy. Energy Sector Development Strategy of the Republic of Serbia by 2015, Official Gazette RS 44/2005.
[16] Development projects of Electric Power Industry of Serbia, Electric Power Industry of Serbia; 2009.
[17] Government of the Republic of Serbia. The National Sustainable Development Strategy of the Republic of Serbia, Official Gazette RS 57/2008.
[18] Government of the Republic of Serbia. The National Strategy for Economic Development of Serbia 2006–2012; 2006.
[19] Government of the Republic of Serbia, Ministry of Environment and Spatial Planning. The National Environmental Protection Program; 2010.
[20] Dodic S, Popov S, Dodic J, Rankovic J, Zavargo Z, Golusin M. An overview of biomass energy utilization in Vojvodina. Renew Sustain Energy Rev 2010;14(1):550–3.
[21] Golusin M, Munitlak Ivanovic O, Bagaric I, Vranjes S. Exploitation of geothermal energy as a priority of sustainable energetic development in Serbia. Renew Sustain Energy Rev 2010;14(2):868–71.
[22] Zekic V, Rodic V, Jovanovic M. Potentials and economic viability of small grain residue use as a source of energy in Serbia. Biomass Bioenergy 2010;34(12):1789–95.
[23] Government of the Republic of Serbia, Ministry of Mining and Energy. Energy Sector Development Strategy Implementation Program 2007–2012, Official Gazette of the Republic of Serbia No. 17/07 and 73/07.
[24] Executive Council of the AP Vojvodina, Provincial Secretariat for Energy and Mineral Resources, Implementation Program of the Energy Development Strategy of the Republic of Serbia in the AP Vojvodina (2007–2012) Amendments and Supplements, September 2009, Novi Sad.
[25] Golusin M, Tesic Z, Ostojic A. The analysis of the renewable energy production sector in Serbia. Renew Sustain Energy Rev 2010;14(5):1477–83.
[26] Government of the Netherlands, Ministry of Economic Affairs, Agriculture and Innovation, EVD, Croatia, Serbia and Bosnia-Herzegovina–Renewable energy, Market survey 2009.

[27] Bogunović A, Bogdanov N. Analysis of Renewable Energy and Its Impact on Rural Development in Serbia, report under FP7 research AgriPolicy; 2009.
[28] Gburčik P, et al. Density of wind energy potential in SR Serbia (Subproject of the project: New renewable energy sources). Serbian Academy of Arts and Sciences; 1984.
[29] Putnik R, et al. Possibilities for wind energy utilization for electricity production. Belgrade: Tekon–tehnokonsalting doo; 2002.
[30] Gburcik P et al. Study of Energy Potential in Serbia for utilization of solar and wind energy, NPEE No. EE704-1052A, Centre for Multidisciplinary Studies of Belgrade University, Belgrade; 2004.
[31] Troen I, Petersen EL. European Wind Atlas Published for the Commission of the European Communities Directorate-General for Science, Research and Development Brussels, Belgium by Risoe National Laboratory, Roskilde, Denmark CEC (1989), European Wind Atlas. Commission of the European Communities; 1989.
[32] Gburčik P, et al. Complementary Regimes of Solar and Wind Energy in Serbia. Geographica Panonica 2006;10:22–5.
[33] Rajković B, Popov Z. Wind speed evaluation on selected locations. Novi Sad: University of Novi Sad, Center for meteorology and environmental predictions; 2005.
[34] Katic V, et al. Wind Atlas of AP Vojvodina. Novi Sad: University of Novi Sad, Faculty of Technical Sciences; 2008.
[35] Katic V et al. Wind Atlas of AP Vojvodina – Appendices, University of Novi Sad, Faculty of Technical Sciences, Novi Sad; 2008.
[36] Ðurišić Ž, Bubnjević M, Mikičić D, Rajaković N. Wind Atlas of Vojvodina, Serbia. In: Proc. of European Wind Energy Conference (EWEC 2007). May 2007.
[37] Government of the Republic of Serbia, Ministry of Mining and Energy. Energy Sector Development Strategy Implementation Program 2007 – 2012 – Amendments, Official Gazette of the Republic of Serbia No. 99/09 and 27/10.
[38] Tesic M, Kiss F, Zavargo Z. Renewable energy policy in the Republic of Serbia. Renew Sustain Energy Rev 2011;15(1):752–8.
[39] Government of the Republic of Serbia, Ministry of Mining and Energy, Energy Law, Official Gazette of Republic Serbia 84/04.
[40] Government of the Republic of Serbia, Ministry of Infrastructure and Energy, Energy Law, Official Gazette of the Republic of Serbia, No. 57/2011 and 80/2011.
[41] Deitz L, Stirton L, Wright K. South East Europe's electricity sector: attractions, obstacles and challenges of Europeanisation. Utilities Policy 2009;17(1):4–12.
[42] Prange-Gstohl H. Enlarging the EU's internal energy market: why would third countries accept EU rule export? Energy Policy 2009;37(12):5296–303.
[43] Mihajlov A. Opportunities and challenges for a sustainable energy policy in SE Europe: SE European Energy Community Treaty. Renew Sustain Energy Rev 2010;14(2):872–5.
[44] Taleski R. Electricity reform in the Republic of Macedonia. Utilities Policy 2009;17(1):88–101. The Political Economy of Electricity Market Reform in South East Europe.
[45] Diaconu O, Oprescu G, Pittman R. Electricity reform in Romania. Utilities Policy 2009;17(1):114–24.
[46] Government of the Republic of Serbia, Decree on the Establishment of Public Company for the transmission of electricity and transmission system control, Official Gazette of the Republic of Serbia No. 12/05 and 58/05.
[47] Government of the Republic of Serbia, Decree on the Establishment of Public enterprise for generation, distribution and trading of electricity, Official Gazette of the Republic of Serbia No. 12/05 and 54/10.
[48] Electric power distribution enterprise Elektrodistribucija Beograd, Rules on electric power distribution system, Official Gazette of the Republic of Serbia No. 5/10.
[49] Government of the Republic of Serbia, Decree on conditions for acquiring the status of a privileged power producers and criteria for evaluating compliance with these conditions, Official Gazette of the Republic of Serbia No. 72/09.
[50] Government of the Republic of Serbia, Decree on incentives for the production of electricity using renewable energy and combined electricity and heat generation, Official Gazette of the Republic of Serbia No. 99/09.
[51] del Rio Gonzalez P. Ten years of renewable electricity policies in Spain: an analysis of successive feed-in tariff reforms. Energy Policy 2008;36(8): 2917–29.
[52] Reiche D, Bechberger M. Policy differences in the promotion of renewable energies in the EU member states. Energy Policy 2004;32(7):843–9.
[53] Szarka J. Wind power, policy learning and paradigm change. Energy Policy 2006;34(17):3041–8.
[54] Wolsink M. Dutch wind power policy: stagnating implementation of renewables. Energy Policy 1996;24(12):1079–88.
[55] Ibenholt K. Explaining learning curves for wind power. Energy Policy 2002;30(13):1181–9.
[56] Georgiou P, Tourkolias C, Diakoulaki D. A roadmap for selecting host countries of wind energy projects in the framework of the clean development mechanism. Renew Sustain Energy Rev 2008;12(3):712–31.
[57] Government of the Republic of Serbia, Law on Planning and Construction, Official Gazette of the Republic of Serbia No. 72/09,81/09 and 64/10.
[58] Government of the Republic of Serbia, Law on Impact Assessment on Environment, Official Gazette of the Republic of Serbia No. 135/04 and 36/09.
[59] Government of the Republic of Serbia, Law on Strategic Environmental Impact Assessment, Official Gazette of the Republic of Serbia No. 135/04 and 88/10.
[60] Government of the Republic of Serbia, The Law on Environmental Protection, Official Gazette of the Republic of Serbia No. 135/04 and 36/09.
[61] Lepotic Kovacevic B, Lazarevic B. Construction of wind farms and electricity generation from wind energy in the Republic of Serbia, US Aid, GTZ GmbH; 2010.
[62] Public Enterprise Electric power industry of Serbia, EPS and renewable energy sources, http://www.eps.rs/razvoj/EPS%20and%20Renewable%20Energy%20Sources.pdf, [last accessed February 2011].
[63] Soderholm P, Ek K, Pettersson M. Wind power development in Sweden: global policies and local obstacles. Renew Sustain Energy Rev 2007;11(3):365–400.
[64] Pettersson M, Ek K, Soderholm K, Soderholm P. Wind power planning and permitting: comparative perspectives from the Nordic countries. Renew Sustain Energy Rev 2010;14(9):3116–23.
[65] UNDP Serbia. Western Balkans Environmental Programme, Instructions for the wind farm impact assessment on the environment; June 2010.
[66] Government of the Republic of Serbia, Decree on determination of Project list for which impact assessment is obligatory and Project list for which environmental impact assessment may be required, Official Gazette of the Republic of Serbia, No. 114/08.
[67] Josimović B, Pucar M. The strategic environmental impact assessment of electric wind energy plants: case study Bavaniste (Serbia). Renew Energy 2010;35:1509–19.
[68] Government of the Republic of Serbia, Law on Nature Protection, Official Gazette of the Republic of Serbia No. 36/09.
[69] Government of the Republic of Serbia, The Law on Waters, Official Gazette of the Republic of Serbia No. 30/10.
[70] Government of the Republic of Serbia, The Law on Public Enterprises and Performing Activities of Public Interest, Official Gazette of the Republic of Serbia, No. 25/2000, 25/2002, 107/2005 and 108/2005.
[71] Government of the Republic of Serbia, Ministry of Mining and Energy, Rulebook on conditions for professional staff and the manner of issuance and revocation of licenses for performing energy activities, Official Gazette of the Republic of Serbia No. 117/05.
[72] Government of the Republic of Serbia, Ministry of Mining and Energy, Rulebook amendments on conditions for professional staff and the manner of issuance and revocation of licenses for performing energy activities, Official Gazette of the Republic of Serbia No. 40/06.
[73] Corrections of rulebook amendments on conditions for professional staff and the manner of issuance and revocation of licenses for performing energy activities, Official Gazette of the Republic of Serbia No. 44/06.
[74] Public Enterprise for electric energy transmission and transmission system control Elektromreža Srbije, Rules on the transmission system, Official Gazette of the Republic of Serbia No. 55/08.
[75] Public Enterprise for electric energy transmission and transmission system control Elektromreža Srbije, Rulebook on the connection object to the system for power transmission; 2006.
[76] http://www.sewea.rs/ [last accessed February 2011].
[77] Bojic M. Education and training in renewable energy sources in Serbia and Montenegro. Renew Energy 2004;29(10):1631–42.
[78] NIP SA. Wind farm feasibility study. Belgrade: Strengthening of the Renewable Energy Department of Serbian Energy Efficiency Agency; 2008.
[79] Kragic R. Wind energy and possibilities for renewable energy utilization in Serbia. Serbia: European Solar Days; 2010.
[80] http://www.seewind.org/ [last accessed February 2011].
[81] Institute for Multidisciplinary Research, Belgrade, Socio-Economic Study at the Project Site Vlasina, deliverable D-2.5, project SEEWIND, 2010.
[82] http://vetar-sunce.imsi.rs/home.php [last accessed February 2011].
[83] Radovanović N, Situation and problems of implementation of projects to build wind farms in Vojvodina, presented at Meeting of the Council for the use of wind energy in Vojvodina, 2010.
[84] Klisić Ð, Zlatanović M, Radovanović I. Windsim® computational flow dynamics model testing using databases from two wind measurement stations. Electronics 2011;15(2):43–8.
[85] Rajaković N, Ðurišić Ž, Bubnjević M, Mikičić D.Prediction of annual electricity production of perspective small wind-plant in the region of Deliblatska Peščara Sixth International Symposium Nikola Tesla. Serbian Academy of Science and Arts; 2006.
[86] http://www.altenergija.org/en/stories/development-wind-energy-belgrade [last accessed January 2012].
[87] Živković P, Ilić G, Vukić M. Wind energy assessment in mountaineous regions of Serbia, 13. In: Symposium of Thermal Engineers of Serbia. University of Niš, Faculty of Mechanical Engineering; 2007.
[88] Raković RM. Vlasina wind project – results and perspectives. Thermal Sci 2006;10(4):143–51.
[89] Žarko Stevanović, V. Turanjanin, Ž. Stevanović, P. Živković. Study of technical and economical potential of electricity production by wind-generators on micro-site TE Kostolac, Research no. EE-273013B, National Program of energy efficiency, Ministry of Science of Serbia; 2007.
[90] Stevanović Ž, Stevanović Ž, Stojanović A. Micro-siting for experimental determination of wind energy potential in region of Kostolac, 13. In: Symposium of Thermal Engineers of Serbia. University of Niš, Faculty of Mechanical Engineering; 2007.
[91] Government of the Republic of Serbia, Ministry of Mining and Energy, www.mem.gov.rs, [last accessed February 2011].
[92] Zlatanović M. The use of wind energy in Serbia – natural conditions and practical policy. Jefferson Institute; 2009.